TG: @Chalnaayaaar

Current Electricity

SOLUTIONS

Exercise-I (Conceptual Questions)

1. $I = \frac{dq}{dt} = \frac{10^6 \times 1.6 \times 10^{-19}}{1} = 1.6 \times 10^{-13}\ A$

2. $\because I = \frac{dQ}{dt} \Rightarrow dQ = Idt$

$Q = \int Idt = \int_2^3 (2t + 3t^2)dt$

on solving $Q = 24\ C$

3. $i = \frac{q}{t} = \frac{10^4 \times 1.6 \times 10^{-19}}{60} = 0.25 \times 10^{-16}\ A$

4. $i = neA\ v_d$

$v_d = \frac{i}{neA} = 1.56 \times 10^{-5}\ m/s$

5. $V_d = \frac{I}{neA} = 2.5 \times 10^{-3}\ m/s$

6. Ampere

7. If no. current passes through a conductor then average velocity of all electrons in conductor is zero for time.

8. $I = neAv_d$

$= \frac{N}{V}eAv_d = \frac{N}{A\ell}eAv_d$

$I = \frac{N}{\ell}ev_d$ solve it.

9. $i = 4.1 \times 10^{18} \times 1.6 \times 10^{-19}$

$= 0.66\ A$ towards right

10. $I = neAv_d$

$\Rightarrow v_d \propto \frac{1}{n}$

$\Rightarrow \frac{v_{d_1}}{v_{d_2}} = \frac{n_2}{n_1} = \frac{4n_1}{n_1} = 4 : 1$

11. $j = \frac{I}{A} = nev_d$

$\frac{4I}{\pi d^2} = nev$ ...(i)

$\frac{16I}{\pi d^2} = nev'$ ...(ii)

From equation (i) & (ii) $\frac{4I}{16I} = \frac{v}{v'} \Rightarrow v' = 4v$

12. $v_d = \frac{i}{Ane}$ As A ↑ so v_d↓ $\Rightarrow v_P > v_Q$

13. $q = \int i\,dt$ = area under i – t curve

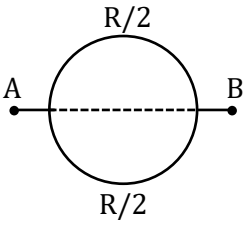
$q_1 = 2C, q_2 = 2C, q_3 = 2C$

So, $q_1 : q_2 : q_3 = 1 : 1 : 1$

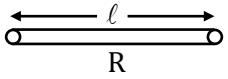
14. $R = \frac{\rho\ell}{A}$

$R_1 = \frac{\rho\ell}{A}$ $R_2 = \rho\left(\frac{4\ell}{A}\right)$ $R_3 = \rho\frac{\ell}{4A}$

$R_3 < R_1 < R_2$



15.



$\Rightarrow R_{AB} = \left(\frac{R/2}{2}\right) = \frac{R}{4}$

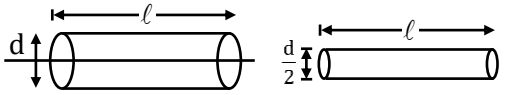
16. Material same $\Rightarrow \rho$ unchanged

$R = \frac{\rho\ell}{A} = \frac{\rho\ell}{\pi a^2} \Rightarrow R \propto \frac{\ell}{a^2}$

Therefore $R' \propto \frac{2\ell}{(2a)^2}$

$\Rightarrow R' = \frac{R}{2}$

17.



Initial volume = final volume

$\frac{\pi d^2\ell}{4} = \frac{\pi d^2 L}{16}$ $\boxed{L = 4\ell}$ $A_f = \frac{A_i}{4}$

$R_i = \frac{\rho\ell}{A_i}$ $R_f = \rho\left(\frac{4\ell}{A_i}\right) = 16\ R_i$

18. T↑ ρ↑ σ↓

$\rho \times \sigma$ = constant

19. $V_{old} = A\ell$

$V = AL \qquad R = \frac{\rho L}{A}$

New

$L' = L + \frac{L}{5} = \frac{6}{5} L$

$V = A'L' = AL$

$A' = \frac{5A}{6}$

$R' = \frac{\rho L'}{A'} = \frac{36}{25}R$

$\%\text{ change} = \frac{R'-R}{R} \times 100 = 44\%$

20. Volume remains same $\Rightarrow AL = A'(2L)$

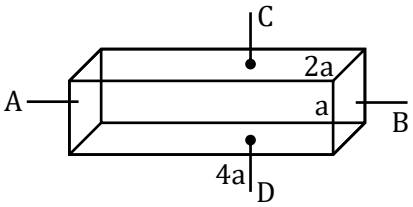
$A' = \frac{A}{2}$; $R_i = \frac{\rho L}{A}$

$R_f = \frac{\rho(2L)}{(A/2)} = 4R_i$

$\%\text{change} = \frac{4R_i - R_i}{R_i} \times 100 = 300\%$

21. Increase and decrease respectively.

22.



$x > z > y$

$\left(R = \rho\frac{\ell}{A}\right)$, A = Area of crossection.

23. The value ρ does not depends on geometry but increases with increase in temperature

24. $R = R_0 (1 + \alpha\Delta T)$

$1 = R_0[1 + \alpha(27)]$

$2 = R_0[1 + \alpha(T)] \quad \Rightarrow \frac{1}{2} = \frac{1+\alpha\times 27}{1+\alpha\times T}$ solve it.

25. For I – V slope = $\frac{I}{V} \propto \frac{1}{R} \propto \frac{1}{T}$ curve

Slope $\downarrow$ R $\uparrow$ T $\uparrow$

$\because R_2 > R_1 \ \therefore T_2 > T_1$

26. $\frac{2R}{2+R} = \frac{6}{5}$

$10R = 12 + 6R$; $R = 3\ \Omega$

27. $R = R_0 (1 + \propto\Delta t)$

$3R_0 = R_0(1 + 4 \times 10^{-3} T)$

$2 = 4 \times 10^{-3} T \quad \Rightarrow \quad T = \frac{1000}{2} = 500°C$

28. For conductor, $T\downarrow \rho\downarrow$

For semiconductor, $T\downarrow \rho\uparrow$

29. $R_1 = R_{01} (1+\alpha\Delta T)$

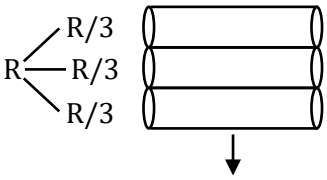
$R_2 = R_{02}(1 -\beta.\Delta T)$

$R_{series} = R_1 + R_2 = R_{01} + (R_{01}\alpha - R_{02}\beta)\Delta T + R_{02}$

Not depend on temperature

$R_{01}\alpha - R_{02}\beta = 0 \quad \Rightarrow \quad \frac{R_{01}}{R_{02}} = \frac{\beta}{\alpha}$

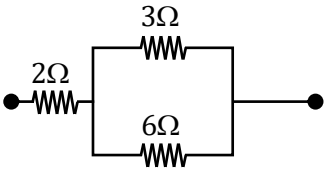
30.



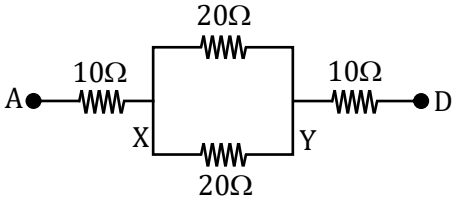
Parallel combination

$R_{eq} = \frac{R}{9}$

31.



32. Redraw circuit



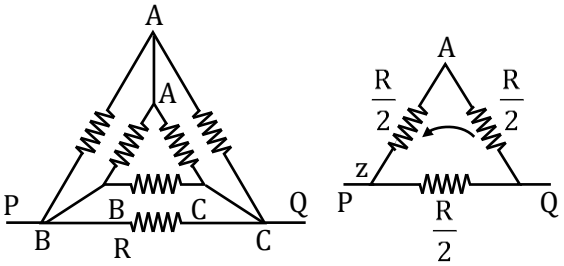
$R_{AD} = 30\ \Omega$

33. $\frac{(R+3).10}{(R+3)+10} + 3 = R$ (given)

solve it $(10R + 30) = (R - 3)(R + 13)$

$10R + 30 = R^2 - 39 + 10R$ or $R = \sqrt{69}\ \Omega$

34.



$R_{eq} = \frac{R}{3}$

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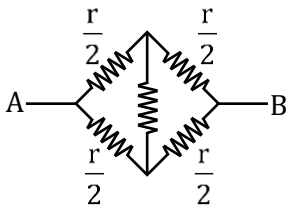
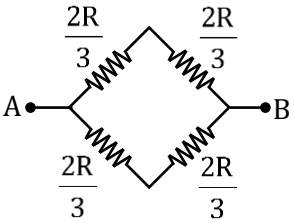
35. After folding symmetry



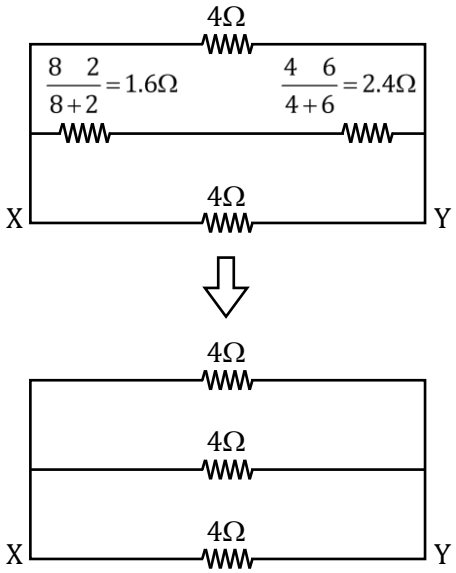
$R_{eq} = \frac{r}{2}$

36. It is balance Wheat Stone Bridge



$R_{AB} = \frac{2R}{3}\Omega$

37. Redrawing the circuit



$Req = \frac{4}{3}$

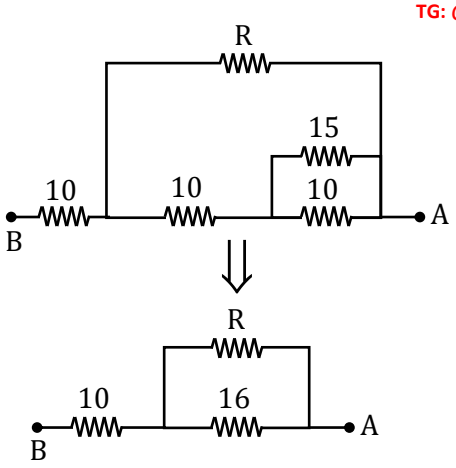
38. When they are connected in parallel

Then $R = \frac{r}{n} \Rightarrow r = nR$

When they are connected in series

Then $R_{eq.} = nr = n \times nR = n^2R$

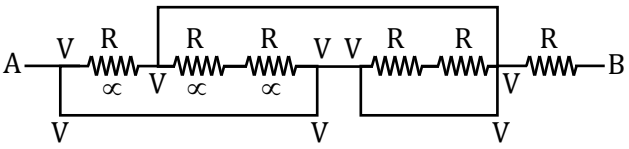
39.



$\frac{16R}{16+R} + 10 = 18$

40. $R_{AB} = 20\Omega$ Multiple W.S.B.

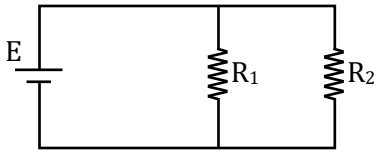
41.



$R_{eq} = R$

42. $R_{eq} = 6\Omega$

43.



$\frac{R_1R_2}{R_1+R_2} = 6\Omega \Rightarrow R_1$ could be $= 8\Omega$

44. $I_{in} = I_{out}$

$10 + 1 + 2 = I \Rightarrow \boxed{I = 13A}$

45. $V_x + 2 \times 1 - 3 \times 1 = V_y$

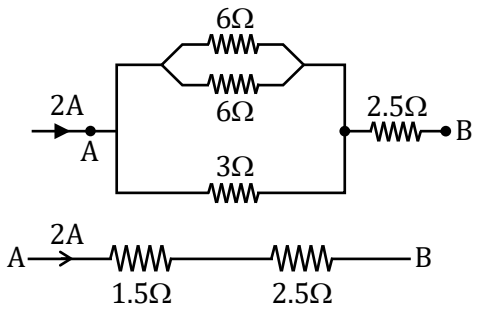
$V_x - V_y = +1$ volt

46. $I = \frac{V}{R_{eq}} = \frac{9}{\frac{9}{5}} = 5$ A

47. $i = 0.25 = \frac{12}{R+6} \Rightarrow R + 6 = 48 \Rightarrow R = 42\ \Omega$

48. $i = 2\ A = \frac{6}{2+R} \Rightarrow R = 1\Omega$

49.



$R_{eq} = 4\Omega$ $V_{eq} = 8V$

50. In loop AHDCBA

$-30\ I_1 - 45 - I_3 - 40\ I_3 = 0$

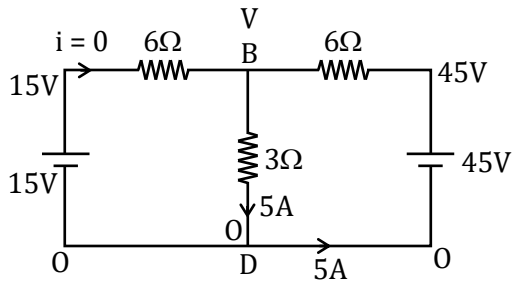
$-30\ I_1 - 41\ I_3 - 45 = 0$

In loop AHDCBA

$-30\ I_1 + 20\ I_2 + 1\ I_2 - 80 = 0$

$-30\ I_1 + 21\ I_2 - 80 = 0$

51.



$$\frac{V-15}{6}+\frac{V}{3}+\frac{V-45}{6}$$

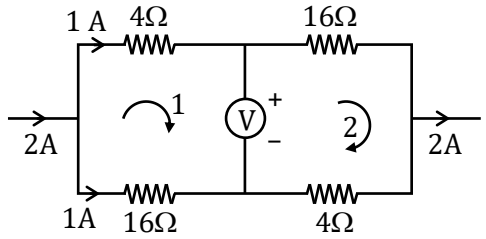
$V - 15 + 2V + V - 45 = 0$

$4V = 60$

$V = 15\ V$

$\therefore\ i_{BD} = \frac{V}{3} = \frac{15}{3}A = 5A$

52.



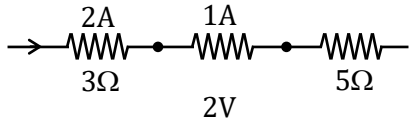
By KVL in loop (1)

$-4 \times 1 - V + 16 \times 1 = 0$

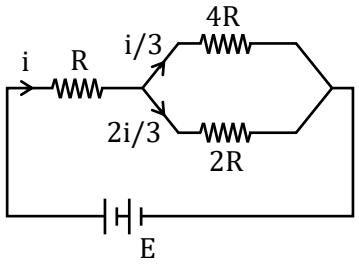
$V = 12$ Volts

53. $V_{JG} = \frac{32}{32+34} \times 60 = 20\,V$

54.

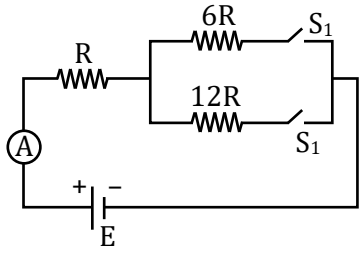


55. $i = \frac{3E}{7R}$



$V = (2R)\ \frac{2}{3}\left(\frac{3E}{7R}\right) = \frac{4}{7}E$

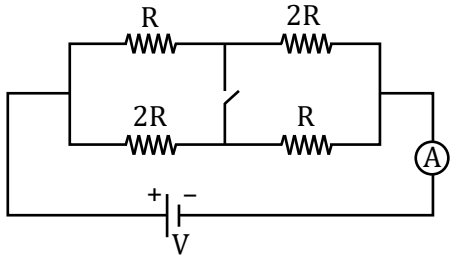
56.



$I_1 = \frac{E}{7R}$ $I_2 = \frac{E}{13R}$ $I_3 = \frac{E}{5R}$

$I_3 > I_1 > I_2$

57.

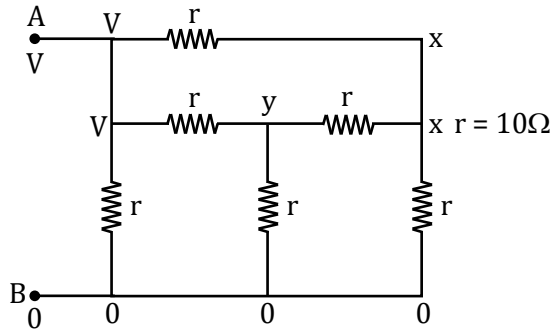


when key open when key closed

$R_{eq} = \frac{3R}{2}$ $R_{eq} = \frac{4R}{3}$

$i_0 = \frac{2V}{3R}$ $i_C = \frac{3V}{4R}$

58.



Balanced Wheat Stone Bridge

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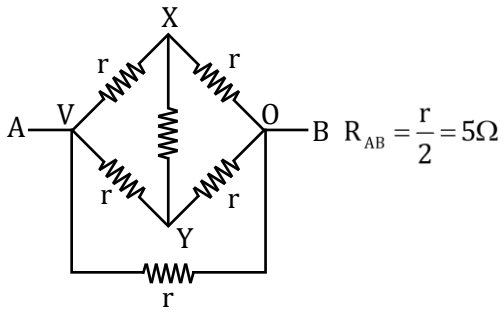
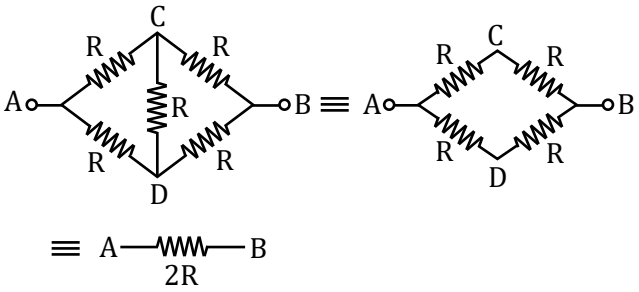


$R_{AB} = \frac{r}{2} = 5\Omega$

59. Given circuit can be reduced to

Balanced Wheat Stone Bridge

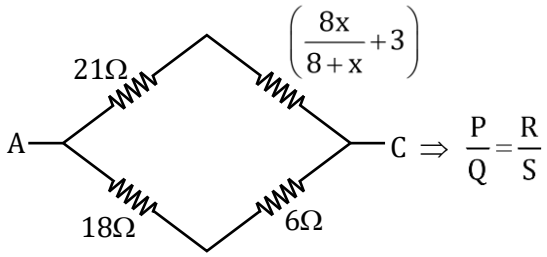


Required current = $\frac{V}{2R}$

60. Option (3) is correct.

61. Wheatstone bridge is in balance condition

62.

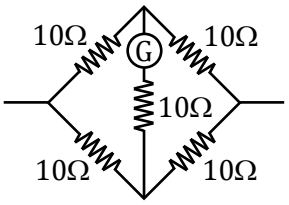


$\Rightarrow \frac{P}{Q} = \frac{R}{S}$

63. For balance wheat stone bridge

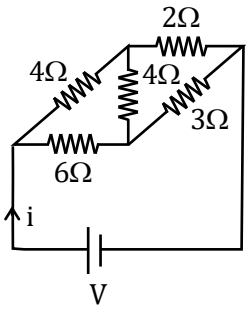
$\frac{16}{4} = \frac{x}{1/2}$; x = 2Ω.

64. R_{eq} = 10 Ω



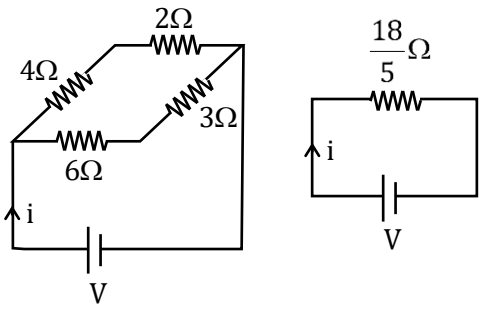
$R_{eq} = 10\Omega$

65.



Here $\frac{4}{6} = \frac{2}{3} \Rightarrow$ Balanced Wheat Stone Bridge

Therefore given circuit can be reduced to



$\Rightarrow i = \frac{5V}{18}$

66. $V = E - Ir = 4 - \frac{10}{20} \times 8 = 0V \left(\because I = \frac{10}{20} = \frac{1}{2}A\right)$

67. When battery is connected to external resistance

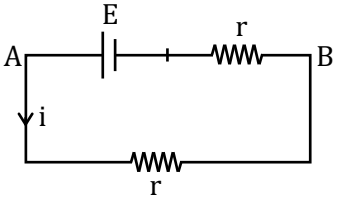
$\frac{4}{2+r} = 1 \Rightarrow r = 2\Omega$

When terminals of battery are connected directly

i = 4/2 = 2A

68. All

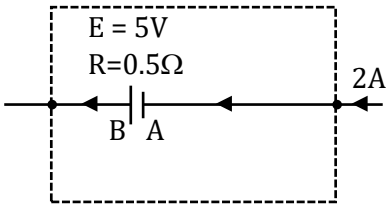
69.



$V_{AB} = 3 \quad \Rightarrow \quad i = 3/r$

$E - ir = 3 \quad \Rightarrow \quad E = 3 + ir = 3 + 3 = 6V$

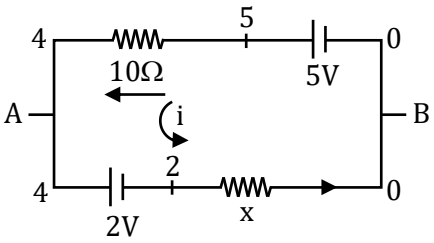
70.



$V_A + 5 - 2 \times 0.5 = V_B$

$10 + 5 - 1 = V_B \Rightarrow V_B = 14V$

71.



$i = \frac{5-4}{10} = 0.1A$

$x \times 0.1 = 2 \Rightarrow x = 20\Omega$

72. emf is basically work

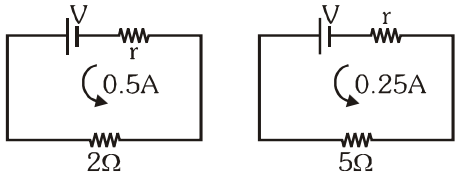
73. $\because I = \frac{E}{2+r}$, terminal potential $\frac{E}{2} = E - Ir$

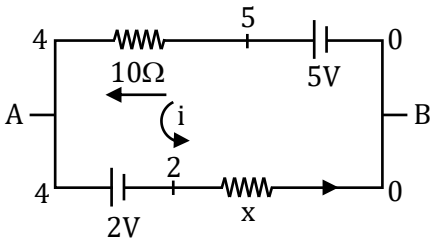
$\Rightarrow \frac{E}{2} = E - \frac{E}{2+r}r$

$\Rightarrow 2 + r = 2r$

$\Rightarrow r = 2\Omega$

74.





V=0.5(2+r) ...(i)

V=0.25(5+r) ...(ii)

for (i) & (ii)

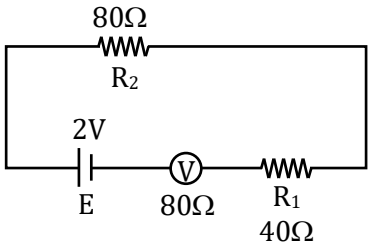
0.5(2+r) = 0.25(5+r)

4 + 2r = 5 + r

r = 1

V = 0.5 × 3 = 1.5V

75.



$i = \frac{2}{200} = 0.01\ A$

V = 0.8 V

76. $0.9 = \frac{V}{2+r}$

$0.3 = \frac{V}{7+r}$

1.8 + 0.9r = 2.1 + 0.3r

0.6r = 0.3

$r = \frac{1}{2}\Omega$

77. for maximum power $R_{internal} = R_{ext.}$

78. $R = \frac{v_0^2}{p_0}$; $P = \frac{V^2}{R} = \frac{V^2}{V_0^2}P_0 = \left(\frac{V}{V_0}\right)^2 P_0$

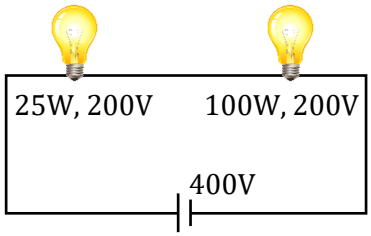
79. $P = \frac{V^2}{R_{eq.}} \Rightarrow R_{eq.} \downarrow P \uparrow$

80. $P = i^2R$ Current is same, so $P \propto R$.

In the first case it is 3r, in second case it is (2/3)r, in III case it is $\frac{r}{3}$ & in IV case the net resistance is $\frac{3r}{2}$

$R_{III} < R_{II} < R_{IV} < R_I \therefore P_{III} < P_{II} < P_{IV} < P_I$

81.



$R = \frac{V_{rated}^2}{P_{rated}}$; $R_1 = \frac{(200)^2}{25}$; $R_2 = \frac{(200)^2}{100}$

$R_1 > R_2$; $V_1 > V_2$

thats why 25 W bulb fuse first

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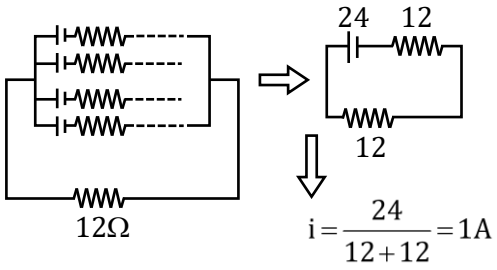
82.



$i = \frac{24}{12+12} = 1A$

For $I_{max} = \frac{nr}{m} = R$ ...(1)

n = number of coloum

m = number of row

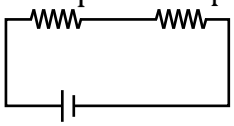
nm = 48 ...(2)

from eq (1) and (2)

n = 12

m = 4

83. $R_1 = \frac{V_1^2}{P}$ $R_2 = \frac{V_2^2}{P}$



$i = \frac{\varepsilon}{\left(\frac{V_1^2}{P} + \frac{V_2^2}{P}\right)}$; Brightness $\propto$ power = (i^2R)

$P_i = \frac{\varepsilon^2 V_1^2}{(V_1^2 + V_2^2)}$

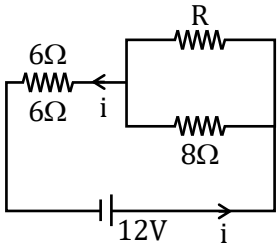
84. $P = \frac{V^2}{R_{eq}}$; $R_{eq} \downarrow P \uparrow$

85. For maximum power internal resistance should be equal to external resistance

$(R_{ent} = R_{Int})$

$R = \frac{r}{2}$

86.



$i^2 6 = 6 \quad \Rightarrow \quad i = \sqrt{\frac{6}{6}} = 1A$

$\left(6 + \frac{8R}{8+R}\right) = 6$

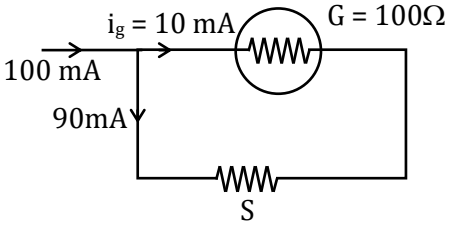
$\frac{8R}{8+R} = 6$; $4R = 24 + 3R \quad \Rightarrow R = 24\ \Omega$

87. max $\rightarrow$ $R = 1 \Rightarrow P = i^2R = 4W$

88. Net resistance of system will decrease.

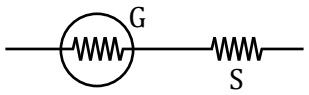
$\therefore$ Reading of A will increase & reading of V will decrease.

89.



$100 \times 10 = 90\ S \Rightarrow S = \frac{100}{9}\Omega$

90.



$V = G\, i_g$

$nV = (G + S)i_g \Rightarrow n = \left(\frac{G+S}{G}\right) \Rightarrow S = (n-1)\, G$

91. Initially

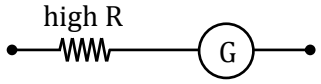
$\frac{R_1}{R_2} = \frac{x}{(1-x)} = \frac{10}{30} \Rightarrow x = 25$ cm

Finally after interchange

$\frac{y}{1-y} = \frac{30}{10} \Rightarrow y = 75$ cm

shifting = 50 cm

92. Voltmeter →



93. If radius of wire is doubled then resistance becomes 1/4 times but ratio of AC : CB remains same.

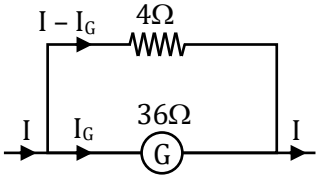
94. $V = I(R + R_A) \Rightarrow 12 = 0.1(R + 20)$

$\Rightarrow R = \frac{12}{0.1} - 20 \quad R = 100\ \Omega$

95. $R = (n-1)G$

Here $n = \frac{10}{1} = 10 \Rightarrow R = (10-1)G = 9G$

96.

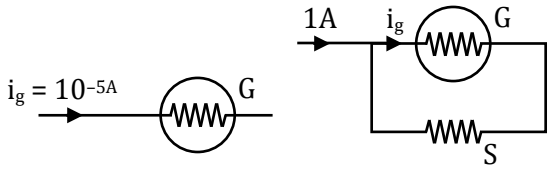


$V_G = V_R$

$\Rightarrow 4(I - I_G) = 36 I_G$

$\Rightarrow 10 I_G = I \Rightarrow \frac{I_G}{I} = \frac{1}{10}$

97.



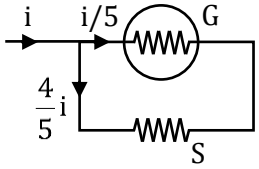
$V = 10^{-3}$ V $\qquad Gi_g = S(1 - i_g)$

$10^{-3} = S(1 - 10^{-5})$

$S \approx 10^{-3}\ \Omega$

98. High resistance $\Rightarrow$ Good voltmeter

99.



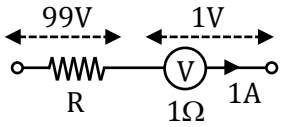
$\frac{i}{5}G = \frac{4i}{5}S\ ;\ S = \frac{G}{4}$

100. $\frac{R_1+10}{R_2} = \frac{50}{50} = 1 \Rightarrow R_1 + 10 = R_2$ ....(i)

$\frac{R_1}{R_2} = \frac{40}{60} \Rightarrow 3R_1 = 2R_2$ ....(ii)

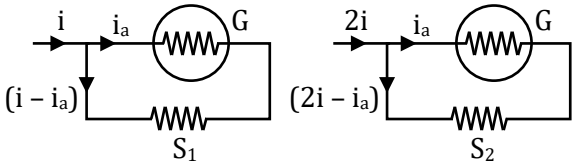
$R_1 + 10 = \frac{3}{2}R_1 \Rightarrow R_1 = 20\ \Omega$

101.



$99 = 1 \times R \Rightarrow R = 99\Omega$

102.



$Gi_a = S_1(i - i_a)$ ...(i)

$Gi_a = (2i - i_a)S_2$ ...(ii)

Equation (i) = (ii)

$S_1(i - i_a) = S_2(2i - i_a) \Rightarrow \frac{S_1}{S_2} = \left(\frac{2i - i_a}{i - i_a}\right)$

103. For internal resistance

$r = \left(\frac{\ell_1 - \ell_2}{\ell_2}\right)R\ ;\ r = \frac{\ell - \frac{\ell}{2}}{\frac{\ell}{2}} \times 2 = 2\Omega$

104. $r = \frac{\ell_1 - \ell_2}{\ell_2} \times R = \frac{60-50}{50} \times 5 = 1\Omega$

105. $r = \left(\frac{\ell_1 - \ell_2}{\ell_2}\right) \times R = \left(\frac{52-40}{40}\right) \times 5$

$= \frac{12}{40} \times 5 = 1.5\Omega$

106. Current through potentiometer wire

$I = \frac{E}{R_{AB}+R} = \frac{2}{40+760} = \frac{1}{400}$

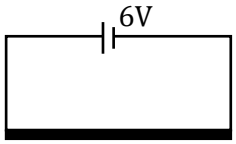
potential difference across potentiometer wire

$V_{AB} = I \times 40 = \frac{1}{400} \times 40 = \left(\frac{1}{10}\right)$volt

$\therefore$ potential gradient $= \frac{V_{AB}}{\ell} = \frac{1}{10 \times 10}$

$= 1 \times 10^{-2}$ volt/meter

107.



3m, 100Ω

Voltage on 50 cm. $= \frac{6}{300} \times 50 = 1$ volt.

108. All of these

109. Uniform and less potential gradient

110. $r = \left(\frac{\ell_0 - \ell_C}{\ell_C}\right)R = \left(\frac{55-50}{50}\right)10 = 1\ \Omega$

[Here $\ell_0 = 55$ cm ; $\ell_C = 50$ cm ; $R = 10\ \Omega$]

111. Reversing the terminals of E_2

112. Potential gradient (PG)

$PG = \frac{E}{R+R_w} \times \frac{R_w}{L_w} = \frac{2}{40+10} \times \frac{10}{1} = 0.4$ V/m

$\therefore E_1 = (PG)\ x\ell = 0.4 \times 40 \times 10^{-2} = 0.16$ V

113. voltage on 40 cm = 4.8 V

Potential gradiant $= \frac{4.8}{40cm}$

voltage on 60 cm so $= \frac{4.8}{40}60 = 7.2$ volt.

114. $E_2 > E_1$

115. $\because E = \left(\frac{V}{L}\right) \times \ell \Rightarrow E = \left(\frac{IR_w}{L_w}\right) \times \ell$

$\Rightarrow E = \frac{E_0}{R+r+R_w} \times \frac{R_w}{L} \times \ell$

$E = \frac{10}{4+1+5} \times \frac{5}{5} \times 3 = 3$volt

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116. $r = \left(\frac{\ell_1 - \ell_2}{\ell_2}\right) R = \frac{150-100}{100} \times 2 = 1\,\Omega$

119. $i = \frac{2}{10+R}$

voltage drop in 10m length = 2 – iR

$V_0 = 2 - \frac{2R}{(10+R)}$

$V_0 = \frac{20}{10+R}$

Potential Gradient $= \frac{V_0}{\ell} = 20$ mV/m

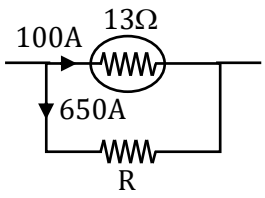
$\Rightarrow \frac{2}{10+R} = 20\times10^{-3} \Rightarrow R = 90\,\Omega$

Exercise-II (Previous Year Questions)

1. $V_A - V_B = \left[V - \left(\frac{V}{8}\times 4\right)\right] - \left[V - \left(\frac{V}{4}\times 1\right)\right]$

$= -\frac{V}{2} + \frac{V}{4} = -\frac{V}{4} \Rightarrow V_B > V_A \Rightarrow$ Ans (4)

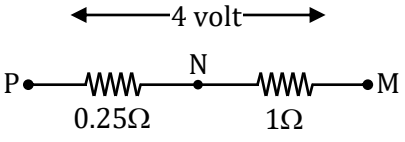
2.



13 x 100 = 650 × R

$\Rightarrow R = 2\Omega$

3. $V_{PM} = 4 \times 1 = 4$ V



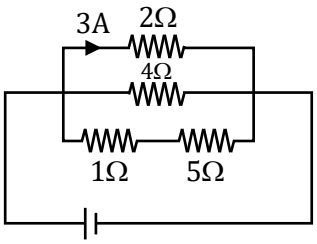
$V_{NM} = \left(\frac{1}{1+0.25}\right) 4 = 3.2$ volt

4. $I_g = \frac{3}{50+2950} \propto 30$, $I_g' = \frac{3}{50+R} \propto 20$

$\Rightarrow \frac{50+R}{50+2950} = \frac{3}{2} \Rightarrow 50 + R = 4500$

$\Rightarrow R = 4450\Omega$

5.



Current through $5\Omega = \frac{6}{1+5} = 1$A

Power dissipated in $5\Omega = I^2R = (1)^2\,5 = 5$W

6. Total resistance of wire = πρr

$R_{AB} = \frac{R}{2} = \left(\frac{1}{2}\right)(\pi r\rho)$

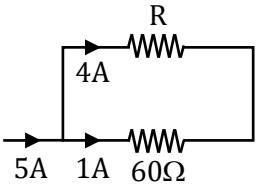
$= \left(\frac{1}{2}\right)(\pi \times 10 \times 10^{-2} \times 12) = 0.6\,\pi\,\Omega$

7. $\varepsilon_2 = i_2 r_2 + (i_1 + i_2)R$

$\varepsilon_1 = i_1 r_1 + (i_1 + i_2)R$

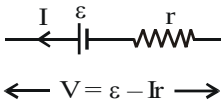
$\varepsilon_2 - \varepsilon_1 = i_2 r_2 - i_1 r_1$

8.



$4R = 60 \times 1 \Rightarrow R = 15\Omega$

9.



slope = –r and intercept = ε

10. $R = k\ell_1$ and $R + X = k\ell_2$

$\Rightarrow X = k\ell_2 - k\ell_1 = k(\ell_2 - \ell_1)$

11. Let required resistance be R then

$(R + R_g)I_g = V \Rightarrow (R + 100)\,(30 \times 10^{-3}) = 30$

$\Rightarrow R = 900\Omega$

12. Option (1) is correct

13. Let internal resistance of battery be r then according to question $\frac{E}{2+r} = 2$ and $\frac{E}{9+r} = 0.5$

$\Rightarrow \frac{2}{0.5} = \frac{9+r}{2+r} \Rightarrow r = \frac{1}{3}\Omega$

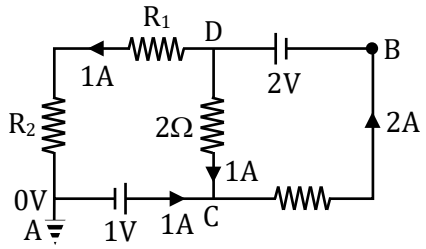
14. Current in 9Ω resistance $=\sqrt{\frac{36}{9}}=2A$

Current in 6Ω resistance $=\frac{9}{6}\times 2=3A$

Current in 2Ω resistance = 2 + 3 = 5A

Potential difference across 2Ω = 2(5) = 10V

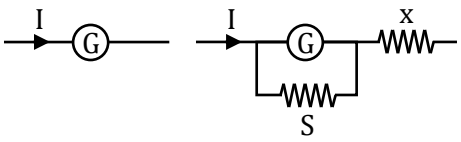
15.



By applying KVL along path ACDB

$V_A + 1 + 2 \times 1 - 2 = V_B \Rightarrow V_B = 1V$

16.



Total current remains same only when total resistance remains same

$G=\frac{GS}{G+S}+x \Rightarrow x=\frac{G^2}{G+S}$

17. $\frac{R_1R_2}{R_1+R_2}=\frac{8}{3}$ & $R_1 + R_2 = 12 \Rightarrow R_1R_2 = 32$

$\Rightarrow R_2 - R_1 = \sqrt{(R_1+R_2)^2-4R_1R_2}$

$= \sqrt{12^2-4\times 32} = 4\Omega$

So $R_1 = 4\Omega$ and $R_2 = 8\Omega$

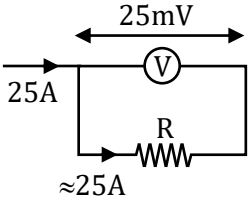
Hence $\frac{\ell_1}{\ell_2}=\frac{4}{8}=\frac{1}{2}$

18. $P \propto V^2$ So $\frac{\Delta P}{P}=2\frac{\Delta V}{V}=5\%$

19. V_B = potential drop across R

$\Rightarrow V_B=\left(\frac{R}{R+R_1}\right)V_A=\left(\frac{100}{100+500}\right)(12)=2V$

20.



Shunt resistance $=\frac{25\times 10^{-3}}{25}=10^{-3}\Omega=0.001\Omega$

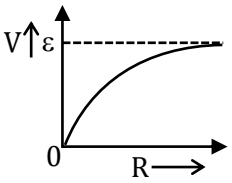
21. $P_{Total}=\frac{V^2}{R_{eq}}$ So $R_{eq}=\frac{V^2}{P_{Total}}=\frac{10\times 10}{30}=\frac{10}{3}$

As $R_{eq}=\frac{R_1R_2}{R_1+R_2} \Rightarrow \frac{10}{3}=\frac{5R}{5+R} \Rightarrow R = 10\Omega$

22. As $V = E - Ir = \frac{ER}{R+r}=\frac{E}{1+\frac{r}{R}}$

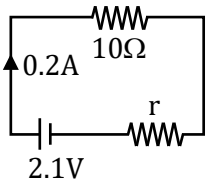
for R = 0 : V = 0

and for $R = \infty$; V = E



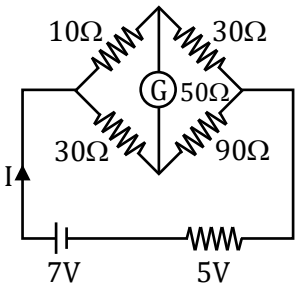
23. $R=\frac{\rho\ell}{A}=\frac{\rho\ell^2}{A\ell} \Rightarrow R \propto \ell^2$

24.



$I=\frac{E}{r+R} \Rightarrow 0.2=\frac{2.1}{r+10} \Rightarrow r=0.5\Omega$

25.



Total resistance of Wheatstone bridge

$=\frac{(40)(120)}{40+120}=30\Omega$

Current through cell $=\frac{7V}{(5+30)\Omega}=\frac{1}{5}A = 0.2\ A$

26. Resistance = (0.5Ω/km) (150 km) = 75Ω

Total voltage drop = (8 V/km) (150 km) = 1200V

Power loss $=\frac{(\Delta V)^2}{R}=\frac{(1200)^2}{75}W$

= 19200 W = 19.2 kW

27. $\frac{5}{R}=\frac{\ell_1}{100-\ell_1}$ and $\frac{5}{R/2}=\frac{1.6\ell_1}{100-1.6\ell_1}$

$\Rightarrow$ R = 15Ω

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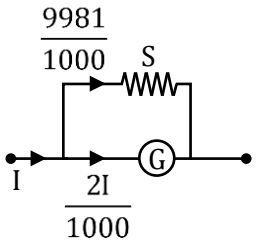
28. Internal resistance,

$$r = \left(\frac{E-V}{V}\right)R = \left(\frac{\ell_1-\ell_2}{\ell_2}\right)R$$

$$= \left(\frac{3-2.85}{2.85}\right)(9.5)\Omega = 0.5\Omega$$

29.



$$\left(\frac{2I}{1000}\right)G = \left(\frac{998I}{1000}\right)S$$

$$\Rightarrow S = \frac{G}{499}$$

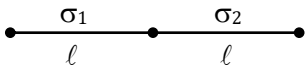
Total resistance of Ammeter

$$R = \frac{SG}{S+G} = \frac{\left(\frac{G}{499}\right)}{\left(\frac{G}{499}\right)+G} = \frac{G}{500}$$

30. Potential gradient $x = \frac{ir}{L} = \frac{E_0}{(r_1+r)}\frac{r}{L}$

$$\therefore \text{ e.m.f. } E = x\ell = \frac{E_0 r}{(r+r_1)}\cdot\frac{\ell}{L}$$

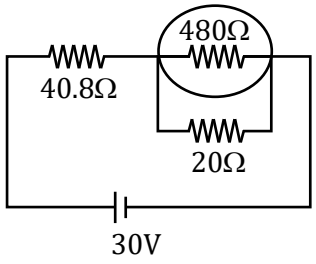
31.



$R_{eq} = R_1 + R_2$

$$\Rightarrow \frac{2\ell}{\sigma_{eq}A} = \frac{\ell}{\sigma_1 A} + \frac{\ell}{\sigma_2 A} \Rightarrow \sigma_{eq} = \frac{2\sigma_1\sigma_2}{\sigma_1+\sigma_2}$$

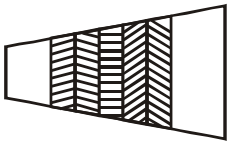
32.



$$R_{eff} = 40.8 + \frac{480\times 20}{480+20} = 40.8 + 19.2 = 60\ \Omega$$

$$I = \frac{V_{eff}}{R_{eff}} = 0.5\,A$$

33. Metallic conductor can be considered as the combination of various conductors connected in series combination. In series combination the current always remains constant.



34. Potential gradient $= \frac{1mV}{cm} = 10^{-3}\,V/cm = 10^{-1}V/m$

Let the resistance to be connected is R then

$$I = \frac{2}{8+R}$$

Potential drop across the potentiometer wire

$$= \frac{8\times 2}{8+R} = \frac{16}{8+R}$$

Potential gradient $= \left(\frac{16}{8+R}\right)\times\frac{1}{4}$ V/m

$$= \frac{4}{8+R} = 0.1 \Rightarrow R = 32\Omega$$

35. Effective resistance of B & C $= \frac{(1.5R)(3R)}{1.5R+3R} = R$

In series sequence $V \propto R$

so voltage across 'A' = voltage across B & C

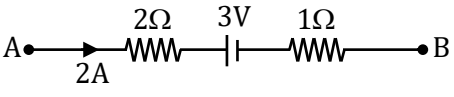
Now B & C are parallel so $V_B = V_C$

$\Rightarrow V_A = V_B = V_C$

36. Here $\frac{E_1+E_2}{E_1-E_2} = \frac{50}{10}$

$$\Rightarrow \frac{2E_1}{2E_2} = \frac{50+10}{50-10} = \frac{60}{40} \Rightarrow \frac{E_1}{E_2} = \frac{3}{2}$$

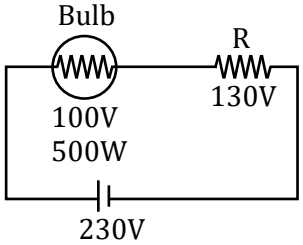
37.



$V_B = V_A - (2\times 2) - 3 - (2\times 1)$

$\Rightarrow V_A - V_B = 9V$

38.



Current through bulb $= \frac{P}{V} = \frac{500W}{100V} = 5A$

Therefore $R = \frac{130V}{5A} = 26\Omega$

39. $R = \frac{\rho\ell}{A} = \frac{\rho\ell^2}{\text{volume}} \Rightarrow R \propto \ell^2$

$\Rightarrow R_2 = n^2R_1$

40. In zero deflection condition, potentiometer draws no current.

41. $I = \frac{E}{nR + R}$ .....(1)

$10I = \frac{E}{\frac{R}{n} + R} = \frac{nE}{R + nR}$ .....(2)

From (1) & (2),

$n\frac{E}{R + nR} = 10\left(\frac{E}{nR + R}\right) \Rightarrow n = 10$

42. $I = \frac{nE}{nr} = \frac{E}{r} = \text{constant}$

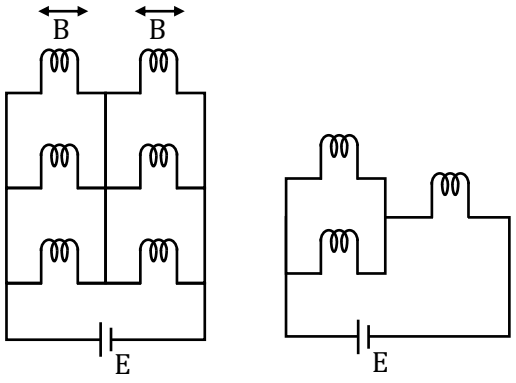
43. $R = (47 \pm 4.7) \times 10^3 = 47 \times 10^3 \pm 10\%\Omega$

As per color code, 4 - Yellow, 7 - Violet, 3 - Orange, 10% - Silver

44. $\frac{\theta}{i} = \frac{50}{10^{-3}} = 5000, \frac{\theta}{V} = 20$

$\frac{\theta/i}{\theta/V} = \frac{5000}{10} = 250 \Rightarrow \frac{V}{i} = R = 250\Omega$

45.



Case-I **Case-II**

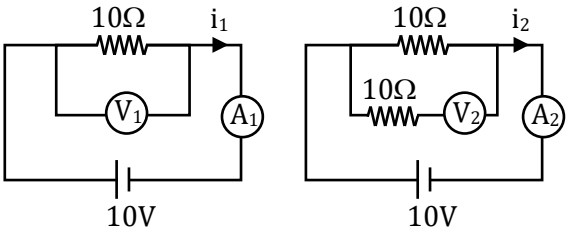
$R_{eq_1} = 2R/3$ $R_{eq_2} = R/2 + R = \frac{3R}{2}$

$P_{eq_1} = \frac{E^2}{2R/3} = \frac{3P}{2}$ $P_{eq_2} = \frac{E^2}{3R/2} = \frac{2P}{3}$

$\therefore P_{eq_1} : P_{eq_2} = 9:4$

46. Fuse is used for protection.

47.



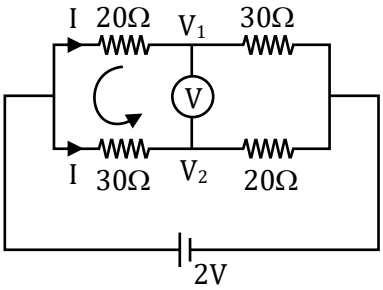
Circuit 1 Circuit 2

10Ω is in series with ideal voltmeter. Therefore it will not affect the circuit (Circuit-2)

$i_1 = \frac{10}{10} = 1A$ $i_2 = \frac{10}{10} = 1A$

$V_1 = 10V$ $V_2 = 10V$

48.



$(V_1 - V_2) = \frac{30}{25} - \frac{20}{25} = \frac{10}{25} = \frac{2}{5} = 0.4\ V$

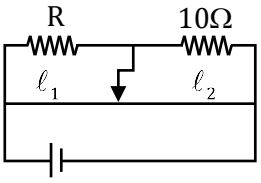
49. Interchanging cell and galvanometer do not effect balance condition.

50. $R = 47 \times 10^1 \pm 5\% = 470\ \Omega, 5\%$

51. $\mu = \frac{v_d}{E} = \frac{7.5 \times 10^{-4}}{3 \times 10^{-10}} = 2.5 \times 10^6\ m^2/V\text{-}s$

52. For some metals like copper, resistivity is nearly proportional to temperature although a non linear region always exists at very low temperature.

53.



$\frac{R}{10} = \frac{\ell_1}{\ell_2} \Rightarrow \frac{R}{10} = \frac{3}{2} \Rightarrow R = 15\Omega$

Length of 15Ω resistance wire is 1.5 m

$\therefore$ length of 1Ω resistance wire $= \frac{1.5}{15} = 0.1$ m

54. $I = \frac{2+4}{4+1+1} = \frac{6V}{6\Omega} = 1\ A$

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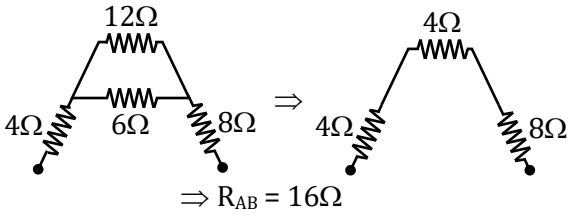
55. By KVL

$-I_2R_2 - E_2 + E_3 + I_3R_1 = 0$

$I_2R_2 + E_2 - E_3 - I_3R_1 = 0$

56.



$\Rightarrow R_{AB} = 16\Omega$

57. Resistance of conductor, $R = \frac{\rho\ell}{A} \Rightarrow A = \frac{\rho\ell}{R}$

$$\Rightarrow \frac{A_1}{A_2} = \frac{\rho_1}{\rho_2} \times \frac{\ell_1}{\ell_2} \times \left(\frac{R_2}{R_1}\right) = 1$$

[$\because R_1 = R_2$, $\ell_1 = \ell_2$ and for same material $\rho_1 = \rho_2$]

58. (A) $\upsilon_d = \left(\frac{eE}{m}\right)\tau$

(B) $J = \sigma E = E/\rho \Rightarrow \rho = E/J$

I $\rho = \frac{E}{ne\upsilon_d}$

$\upsilon_d = \frac{E}{ne\rho}$

$\frac{eE}{m}\tau = \frac{E}{ne\rho}$

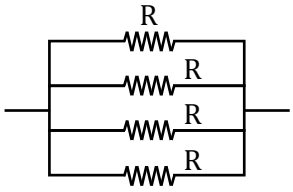
$\tau = \frac{m}{ne^2\rho}$

(D) $I = neA\upsilon_d$

$\frac{i}{A} = ne\upsilon_d$

$J = ne\upsilon_d$

59. $R_l = \frac{R}{4} = 0.25\,\Omega$



$R = 1\,\Omega$

$R_{series} = 4R = 4(1) = 4\Omega$

60. $\frac{E_1}{E_2} = \frac{\phi\ell_1}{\phi\ell_2}$

$\frac{1.5}{2.5} = \frac{36}{\ell_2} \Rightarrow \ell_2 = 36 \times \frac{5}{3} = 60\,cm$

61. $V = ir$

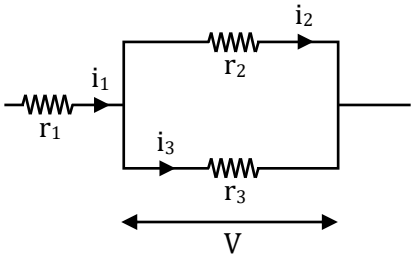
$i = \frac{V}{r}$

$i \propto \frac{1}{r}$ [V is same for r_2 & r_3]

$\frac{i_2}{i_3} = \frac{r_3}{r_2}$

$i_3 = \frac{r_2}{r_2 + r_3} i_1$

$\frac{i_3}{i_1} = \frac{r_2}{r_2 + r_3}$



Exercise-III (Analytical Questions)

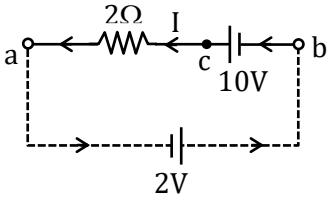
1. $\because V_1$ and V_2 are in series

$\therefore V \propto R$

$\therefore V_1 \neq V_2$ (as $R_1 \neq R_2$)

$V_1 + V_2 = V_3$ (as V is same in parallel)

2.



$I = \frac{12}{2} = 6A$

Apply KVL from a to c

$V_a + 6 \times 2 = V_c$

$V_a - V_c = -12$ Volt

3. $E = 10V$, $I_{max} = \frac{E}{r} = 2$ Amp.

$r = \frac{E}{2} \Rightarrow r = \frac{10}{2} = 5\Omega$

4. Sensitivity $\propto \frac{1}{P.G.} \propto \frac{L_{pm}}{V_{pm}}$

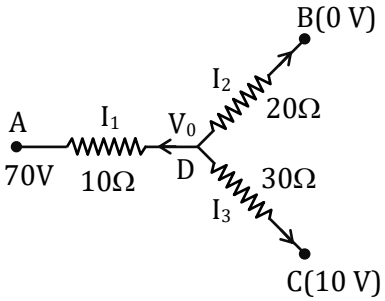
5. $\frac{V^2}{R}t$ = constant

$\therefore t \propto R$

In series $t_s = t_1 + t_2$

In parallel $t_p = \frac{t_1 t_2}{t_1 + t_2}$

6.



$I_1 + I_2 + I_3 = 0$

$\frac{V_0-70}{10} + \frac{V_0-0}{20} + \frac{V_0-10}{30} = 0$

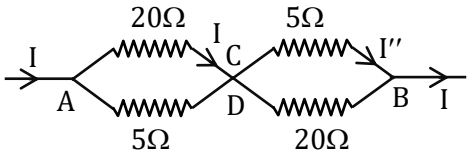
$\Rightarrow V_0 = 40$ volt

$I_1 = 3A$

$I_2 = 2A$

$I_3 = 1A$

7.

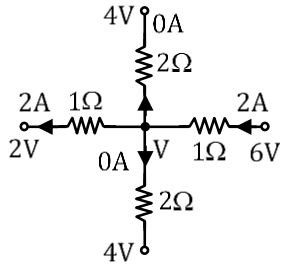


$I' = \frac{5}{25}I = \frac{I}{5}$ $\quad R_{eq} = 4 + 4 = 8\Omega$

$I'' = \frac{20}{25}I = \frac{4I}{5}$ $\quad$ Also $= V_C = V_D$

Current in DC $= \frac{4I}{5} - \frac{I}{5} = 3I/5$

8.



$\frac{V-2}{1} + \frac{V-6}{1} + \frac{V-4}{2} + \frac{V-4}{2} = 0$

$2V - 4 + 2V - 12 + V - 4 + V - 4 = 0$

$6V = 24$

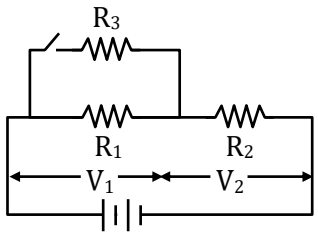
$V = 4$

$2A, -2A, 0A, 0A$

9. i = constant

as area $\uparrow \Rightarrow R/\ell \downarrow$ & $E \downarrow \Rightarrow \frac{V}{L} \downarrow$ & $J = \frac{i}{A} \downarrow$

10.



After closing the switch $V_1 \downarrow$ and $V_2 \uparrow$

$\Rightarrow$ i through $R_1 \downarrow$ and i through $R_2 \uparrow$.

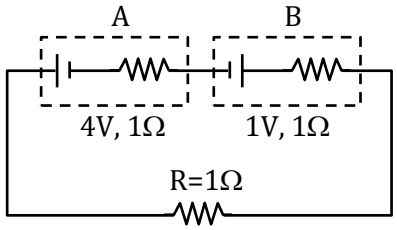
11. $V = \frac{\text{Work}}{q} = \frac{[ML^2T^{-2}]}{[AT]} = [ML^2T^{-3}A^{-1}]$

$R = \frac{V}{i} = [ML^2T^{-3}A^{-2}]$

$\rho = \frac{RA}{\ell} = [ML^3T^{-3}A^{-2}]$

$\sigma = \frac{1}{\rho} = [M^{-1}L^{-3}T^3A^2]$

12.



$i = \frac{4-1}{1+1+1} = 1A$

Now TPD of A $= 4 - 1 \times 1 = 3V$

TPD of B $= 1 + 1 \times 1 = 2V$

Power consumed by R $= 1^2 \times 1 = 1W$

P.D. of R $= 1 \times 1 = 1V$

13. Increase in temperature causes atoms to vibrate more, which increases the number of collisions electrons suffer and decrease the drift velocity.

OR $\vec{v}_d = \mu E = \left(\frac{e\tau}{m}\right)\vec{E}$ & $\sigma = \frac{ne^2\tau}{m}$

$v_d \propto \tau$, $\sigma \propto \tau$ (temp. $\uparrow$; $\tau \downarrow$)

14. $S(i - i_0) = i_0G$

$\Rightarrow i = i_0\left(1 + \frac{G}{S}\right)$

$\therefore$ As $S \uparrow$ $i \downarrow$

$\therefore$ Value of shunt is more in mili ammeter.

$R_{net} = \frac{GS}{S+G} = \frac{G}{1+\frac{G}{S}}$

$\therefore S \uparrow \Rightarrow R_{net} \uparrow$

$\Rightarrow R_{\text{mili ammeter}} > R_{\text{ammeter}}$

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15. A current carrying wire is not charged.

16. In balanced condition, current through galvanometer is zero and does not affect main current.

17. For rating, $P=\frac{V^2}{R}$ $\therefore P\uparrow \Rightarrow R\downarrow$

18. * For maximum power R = r

* $P = I^2R \propto I^2$ (if R = constant)

19. At higher currents, joule's heating will be larger, increasing the temperature sharply. Since,

$R = R_0(1 + \propto \Delta T)$, resistance varies and $V \propto I$ doesn't hold anymore.

20. For meter bridge experiment, unknown resistance $S=\frac{100-\ell}{\ell}R$

21. $\Delta KE = q(\Delta V)$

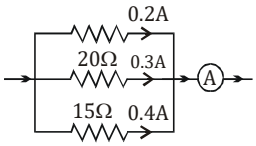
22. Unknown emf should not be more than voltage across potentiometer wire.

23. As i changes (in same resistor); n remain constant

by i = JA ; J become double

by i = $nAeV_d$; V_d become double

25.



$0.2R_1 = 20 \times 0.3 = 15 \times 0.4$

27. $\ell_{min}=\left(\frac{100}{16}\times 10\right)$ hen $R_{rheostat}=0$

30. For (A) :

$$\vec{E}=-\frac{\partial V}{\partial x}\hat{i}-\frac{\partial V}{\partial y}\hat{j}-\frac{\partial V}{\partial z}\hat{k}=\frac{1}{x^2}\hat{i}+\frac{1}{y^2}\hat{j}+\frac{1}{z^2}\hat{k}$$

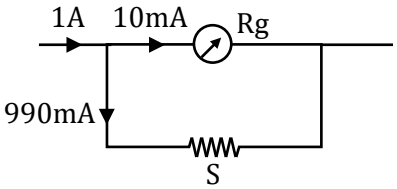
$$\Rightarrow |\vec{E}|=|\hat{i}+\hat{j}+\hat{k}|=\sqrt{3}\ N/C$$

For (B) :

$I=\frac{dQ}{dt}=4-4t$, current will be zero at t=1s

Total heat produced

$$\int_0^1 I^2Rdt=\int_0^1 (4-4t)^2(6)dt=(16\times 6)\left[\frac{(1-t)^2}{-3}\right]_0^1=32J$$



For(C) (10 mA) (Rg) = (990 mA) (s)

$\Rightarrow s=\frac{0.99}{99}=0.01\Omega$

For(D) $U=-\vec{p}.\vec{E}$ Here $\vec{p}=\pm qd\hat{i}$

$|\vec{P}| = (10 \times 10^{-3})\ (8 \times 10^{-2}) = \pm\ (8 \times 10^{-4})\ \hat{i}$ C-m

$U = -pE\cos\theta$

$U = (8 \times 10^{-4})\ (500)$

$U = 0.4$ J